Use of AIRS data in the Joint Center for Satellite Data Assimilation

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AIRS Science Team Meeting, October 2007

Overview

- AIRS data at NCEP/EMC
- AIRS radiances and retrievals
- AIRS PSC detection
- *Cloudy radiances*

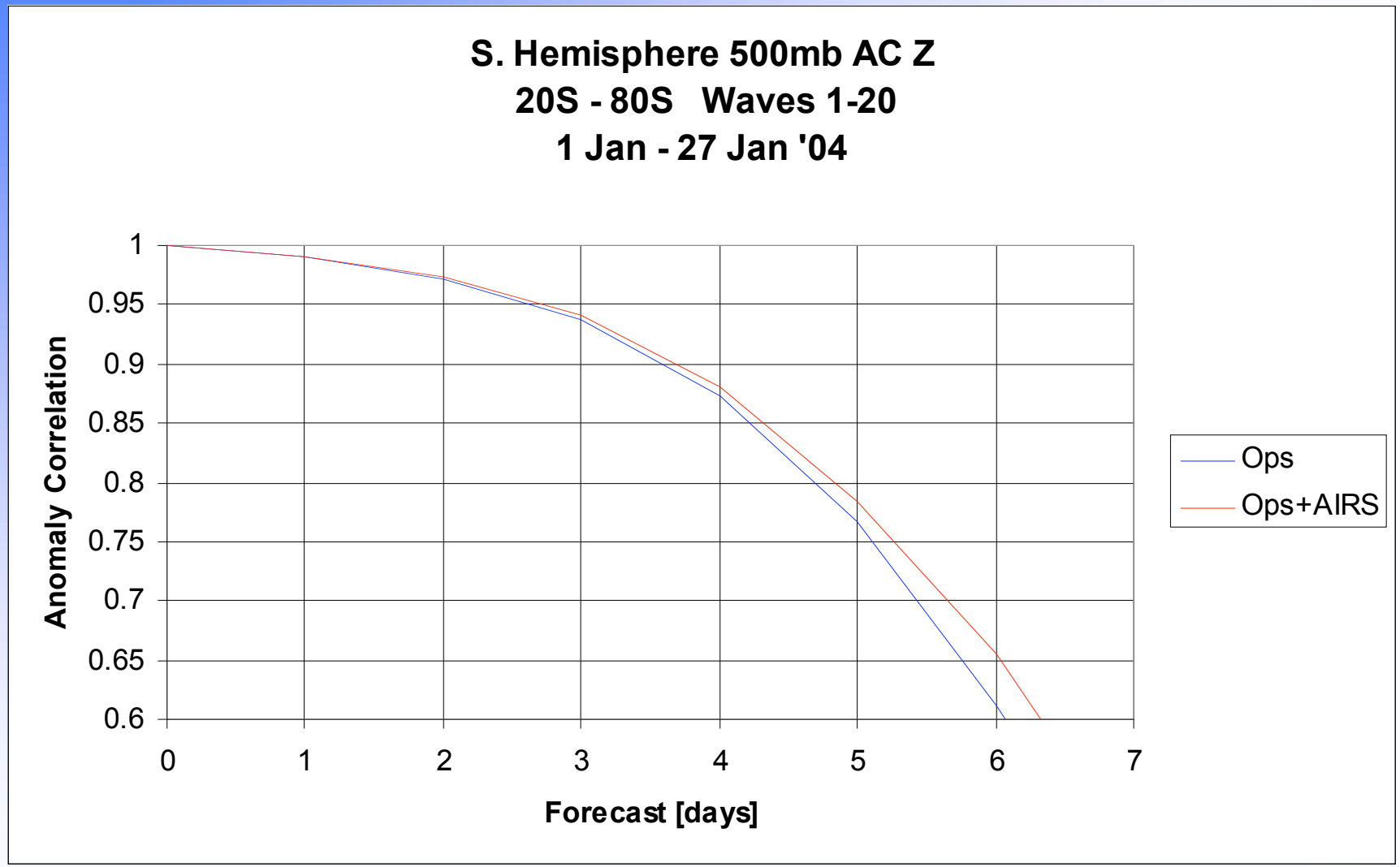


Figure 1(b). 500hPa Z Anomaly Correlations for the GFS with (Ops.+AIRS) and without (Ops.) AIRS data, Southern hemisphere, January 2004

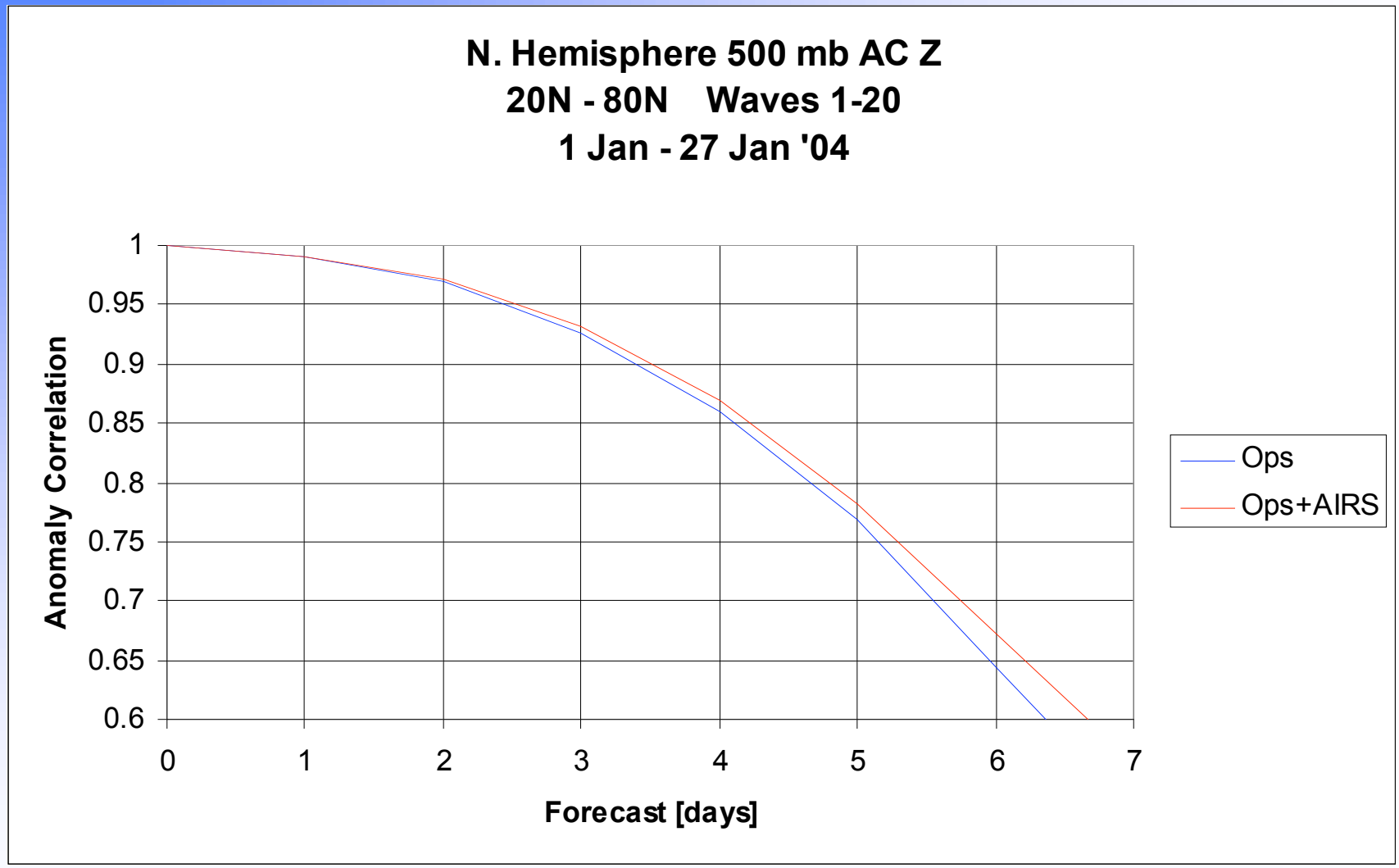
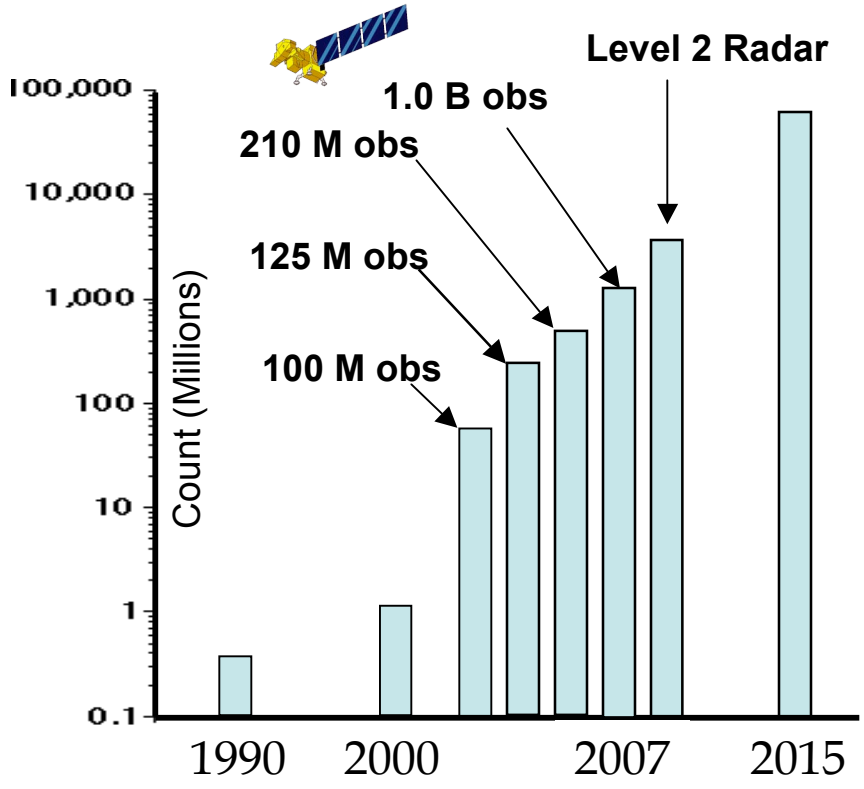


Figure 3(b). 500hPa Z Anomaly Correlations for the GFS with (Ops.+AIRS) and without (Ops.) AIRS data, Northern hemisphere, January 2004

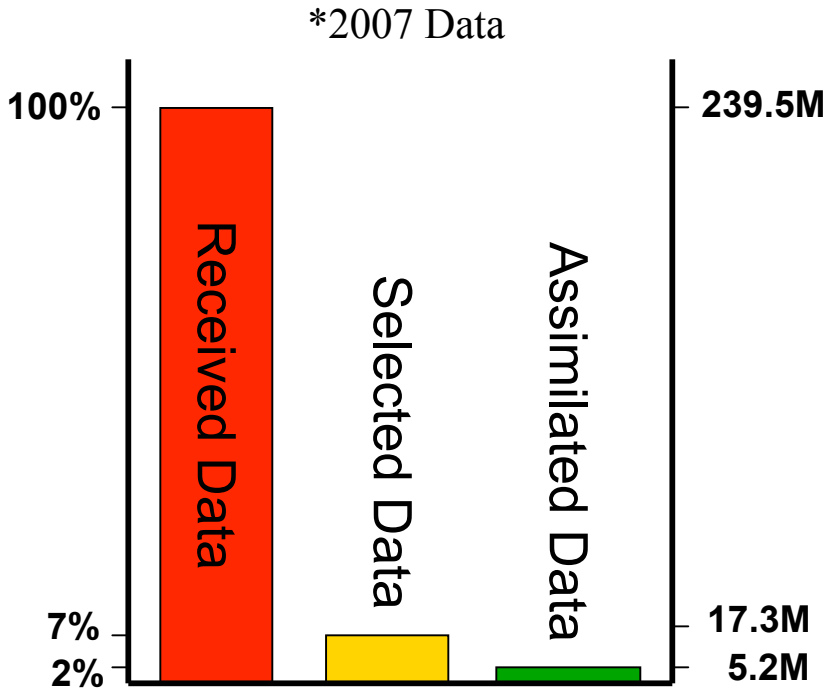
NASA-NOAA-DOD Joint Center for Satellite Data Assimilation (JCSDA)

Satellite Data Ingest

Daily Satellite & Radar Observation Count



Daily Percentage of Data Ingested into Models



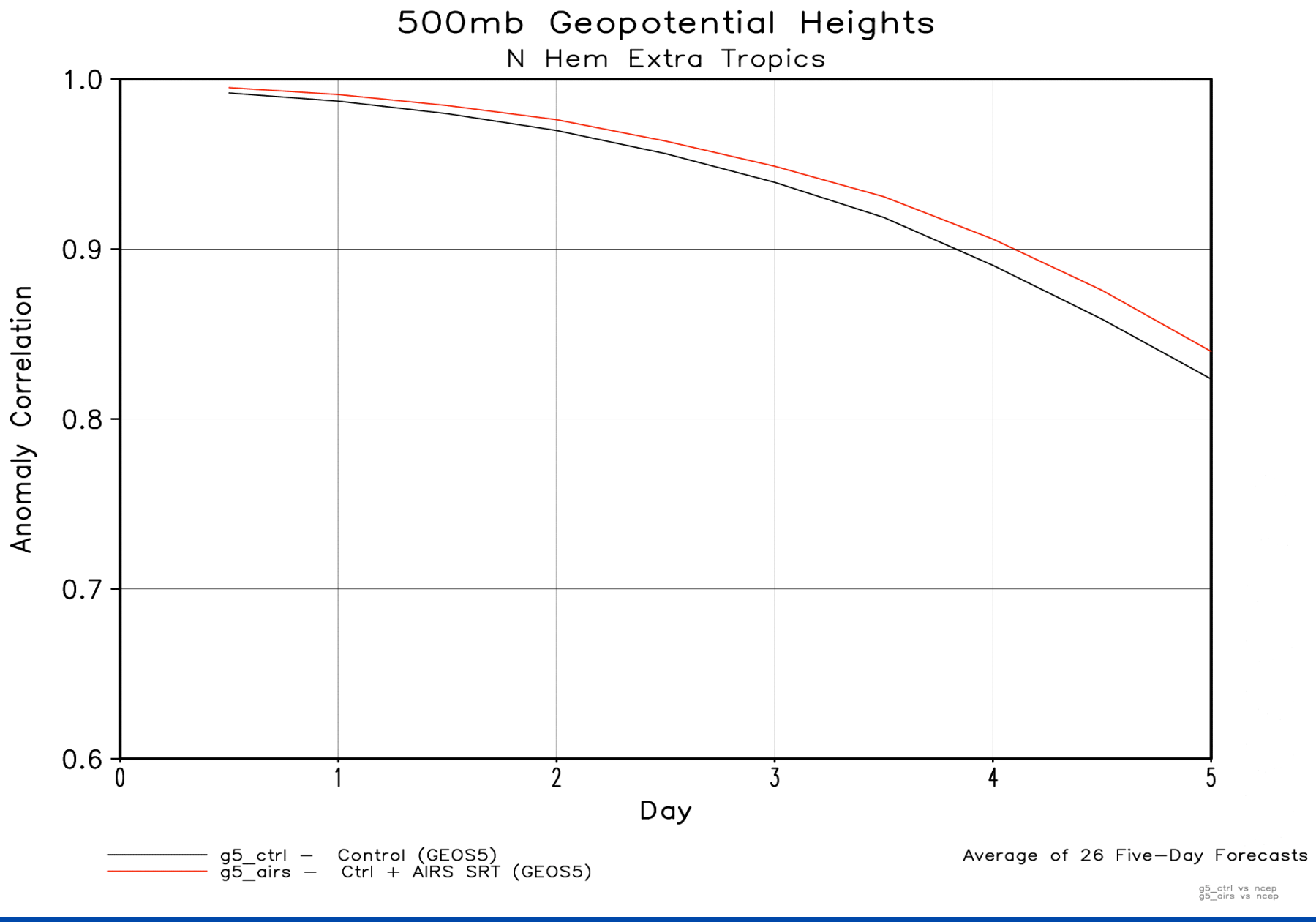
Motivating Factors for the JCSDA

Five Order of Magnitude Increases in Satellite Data Over Fifteen Years (2000-2015)

Received = All observations received operationally from providers
Selected = Observations selected as suitable for use
Assimilated = Observations actually used by models

Result – average of 26 GEOS-5 AIRS forecasts vs. 26 GEOS-5 Control forecasts

Slide by Reale et al.

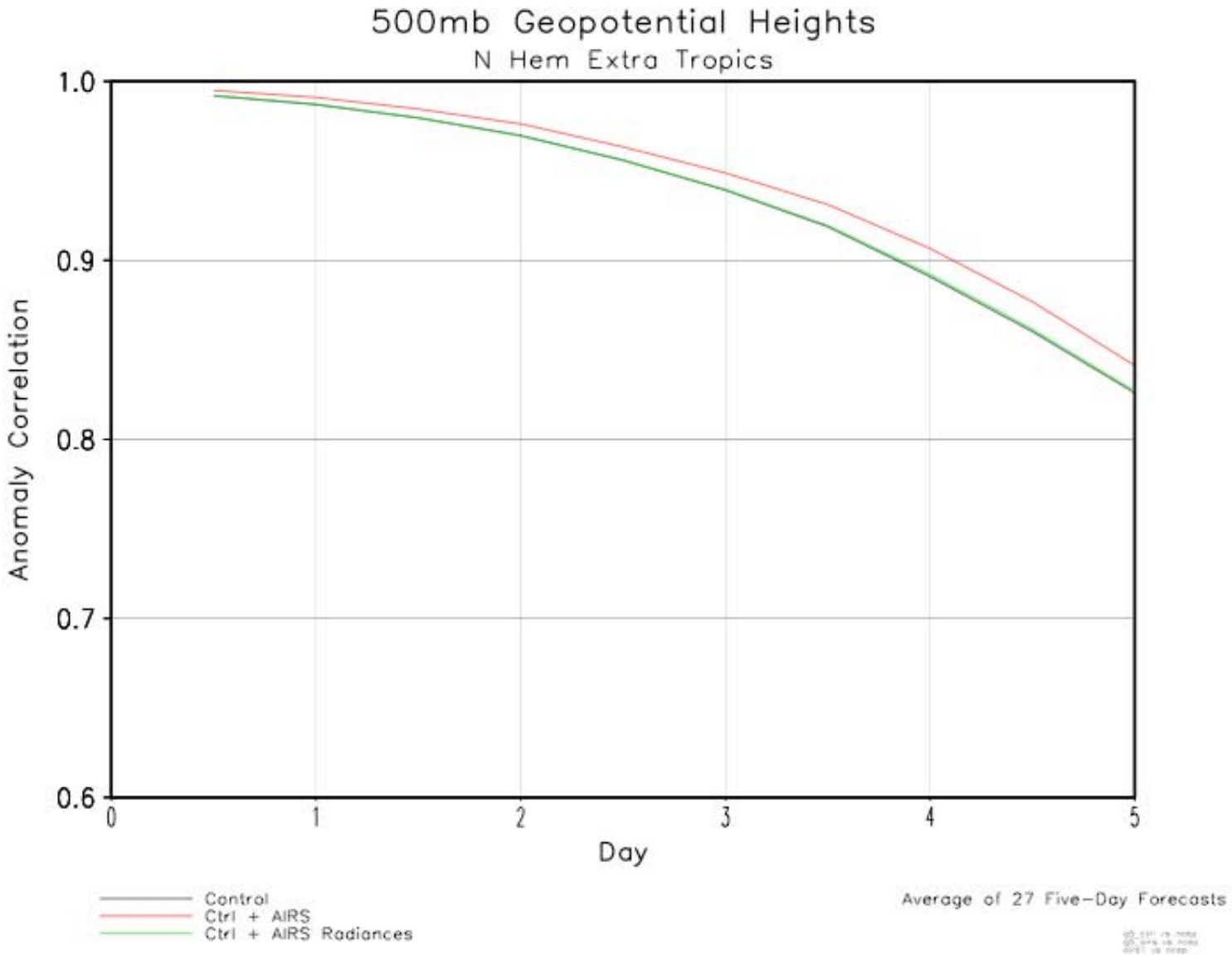


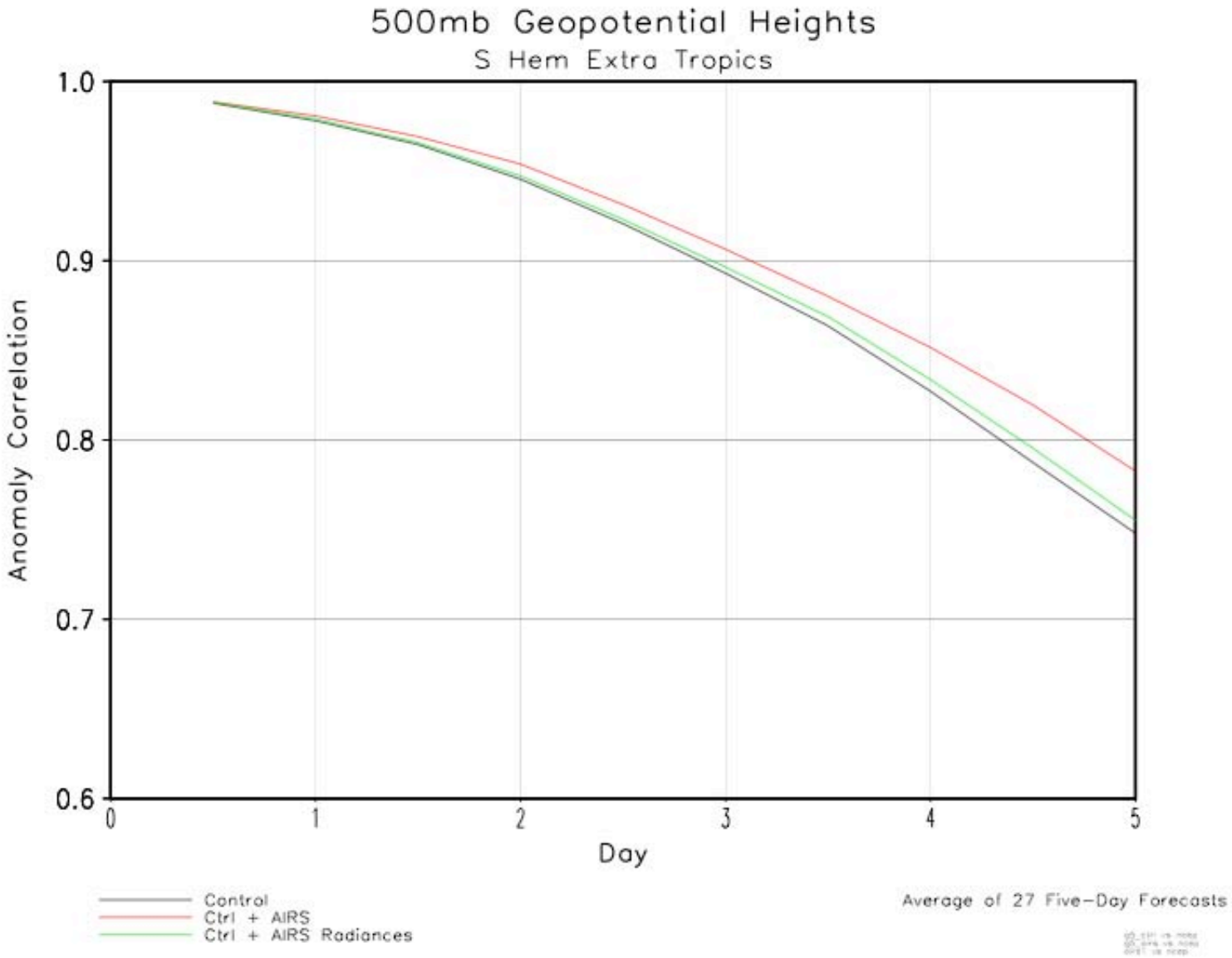
AIRS radiance vs. retrievals comparison

- One period (January 2003), three experiments:
  - Control; including all observations used for routine operations: radiosonde, surface, aircraft and satellite measurements
  - AIRS-1; control + AIRS clear radiances (251 channels)
  - AIRS-2; control + AIRS Science Team temperature retrievals (v. 4.7);

- Assimilation system is GEOS-5, beta7p4; horizontal resolution 1 by 1 ¼ degrees
  - fv-model
  - GSI analysis
    - radiance-based system; AIRS retrievals assimilated as if they were radiosondes

- 27 cases: five-day forecast every day at 00Z; verification carried out against self and NCEP operational analysis (only NCEP shown here)


500mb Geopotential Heights
N Hem Extra Tropics
Anomaly Correlation
1.0
0.9
0.8
0.7
0.6
0
1
2
3
4
5
Day
Control
Ctrl + AIRS
Ctrl + AIRS Radiances
Average of 27 Five-Day Forecasts


500mb Geopotential Heights
S Hem Extra Tropics
1.0
0.9
0.8
0.7
0.6
Anomaly Correlation
0
1
2
3
4
5
Day
Control
Ctrl + AIRS
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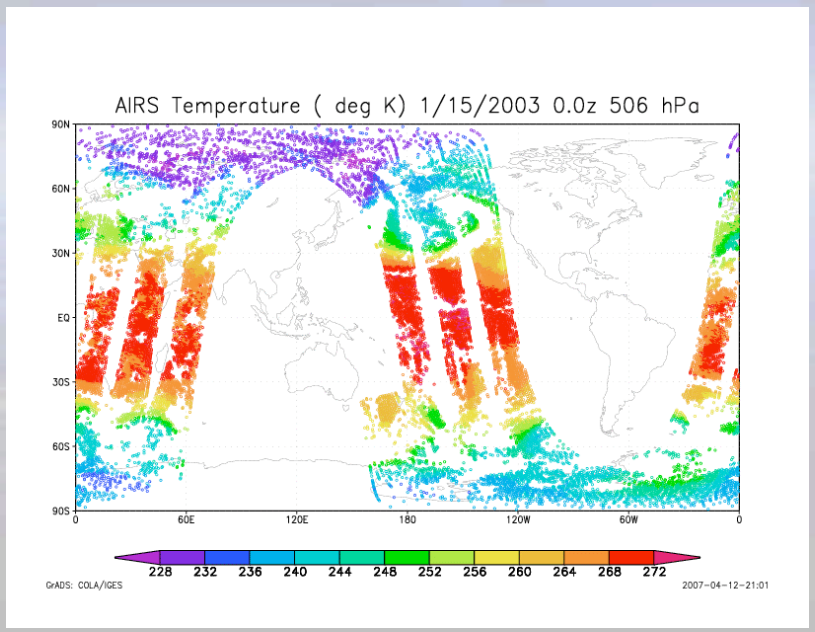
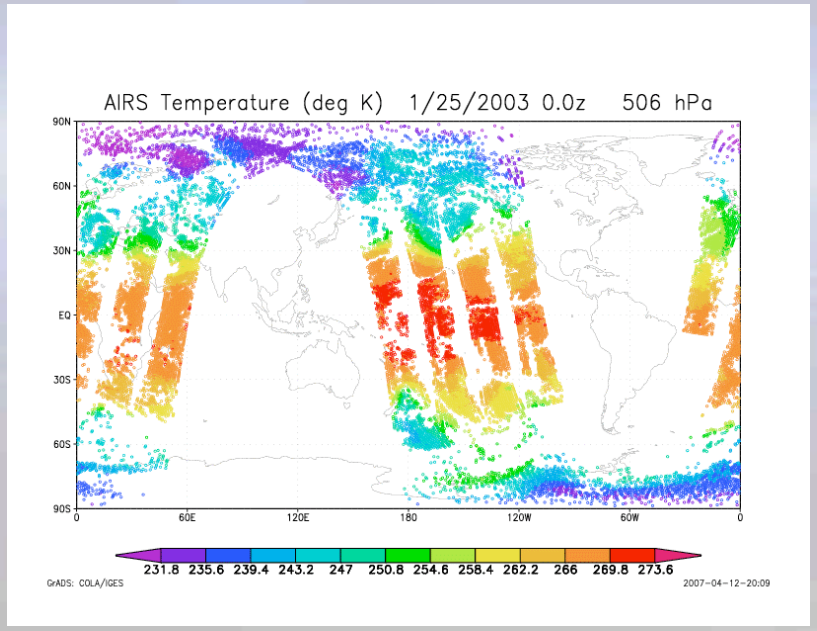
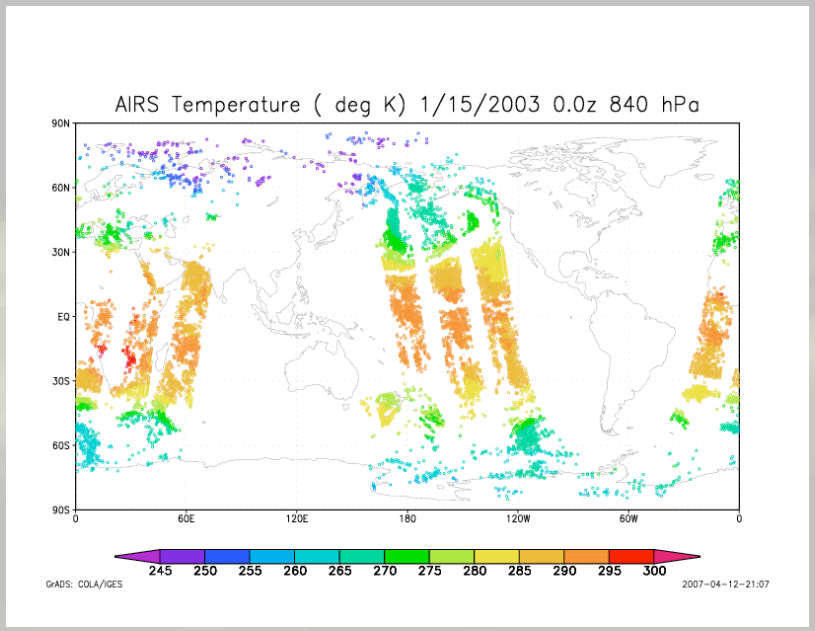
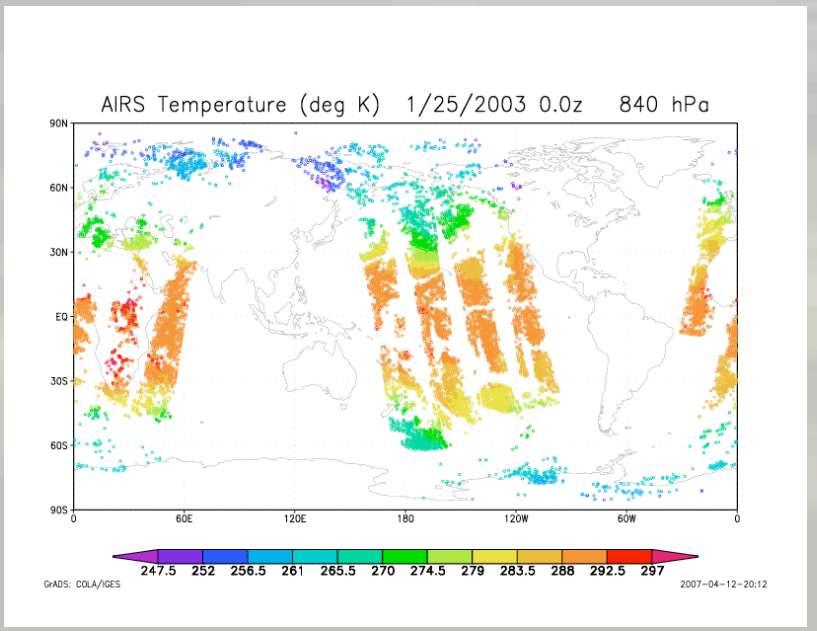
Average of 27 Five-Day Forecasts

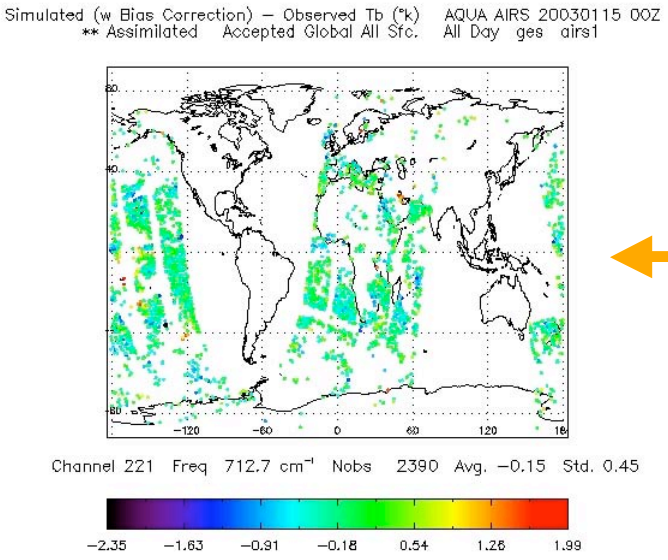

AIRS Temperature (deg K) 1/15/2003 0.0z 506 hPa
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
228 232 236 240 244 248 252 256 260 264 268 272
GrADS: COLA/IGES
2007-04-12-21:01

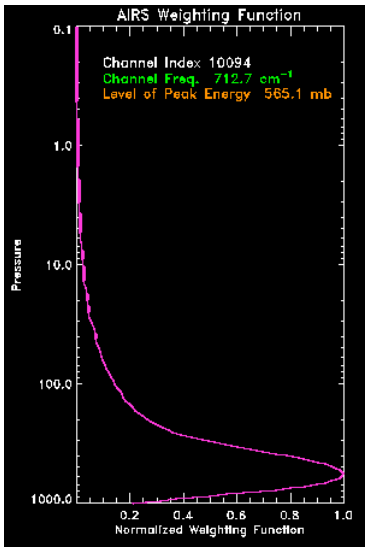

AIRS Temperature (deg K) 1/25/2003 0.0z 506 hPa
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
231.8 235.6 239.4 243.2 247 250.8 254.6 258.4 262.2 266 269.8 273.6
GrADS: COLA/IGES
2007-04-12-20:09

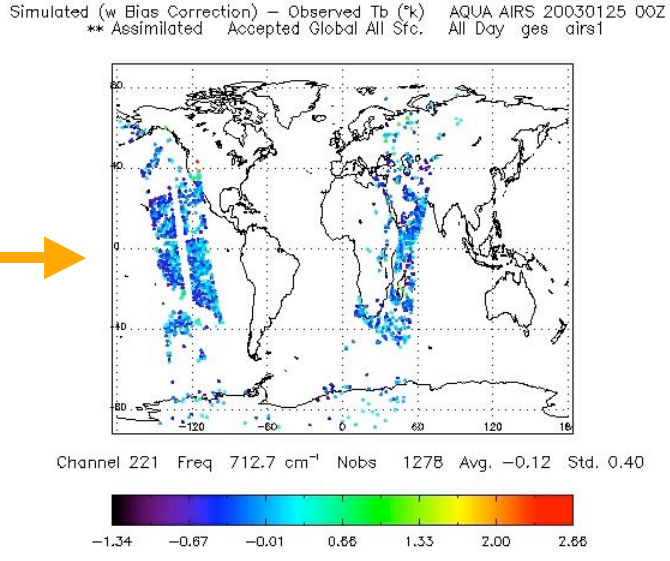

AIRS Temperature (deg K) 1/15/2003 0.0z 840 hPa
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
245 250 255 260 265 270 275 280 285 290 295 300
GrADS: COLA/IGES
2007-04-12-21:07

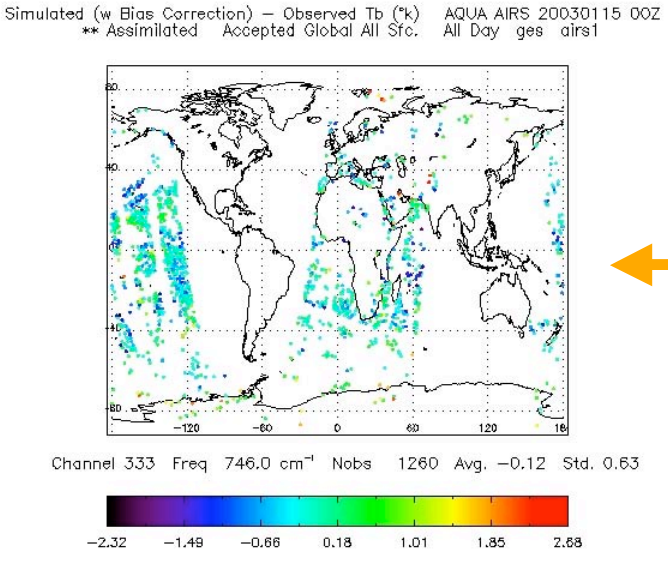

AIRS Temperature (deg K) 1/25/2003 0.0z 840 hPa
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
247.5 252 256.5 261 265.5 270 274.5 279 283.5 288 292.5 297
GrADS: COLA/IGES
2007-04-12-20:12

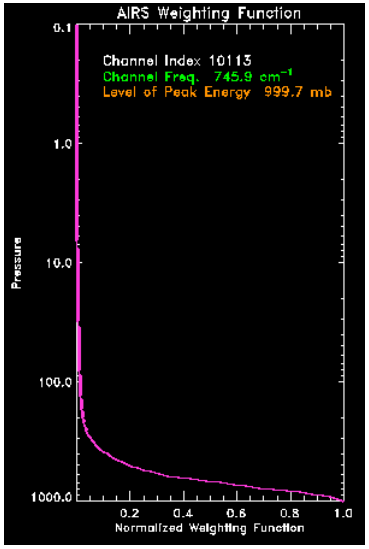
Radiances Used in Analysis for Two Low Peaking Tropospheric AIRS Channels

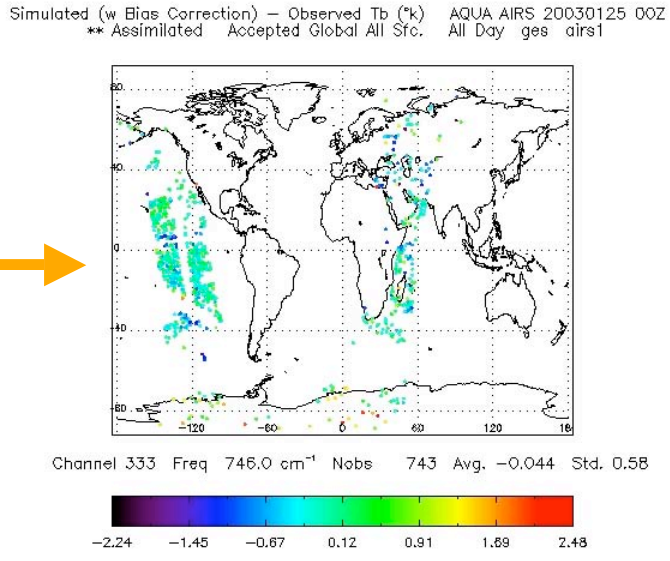












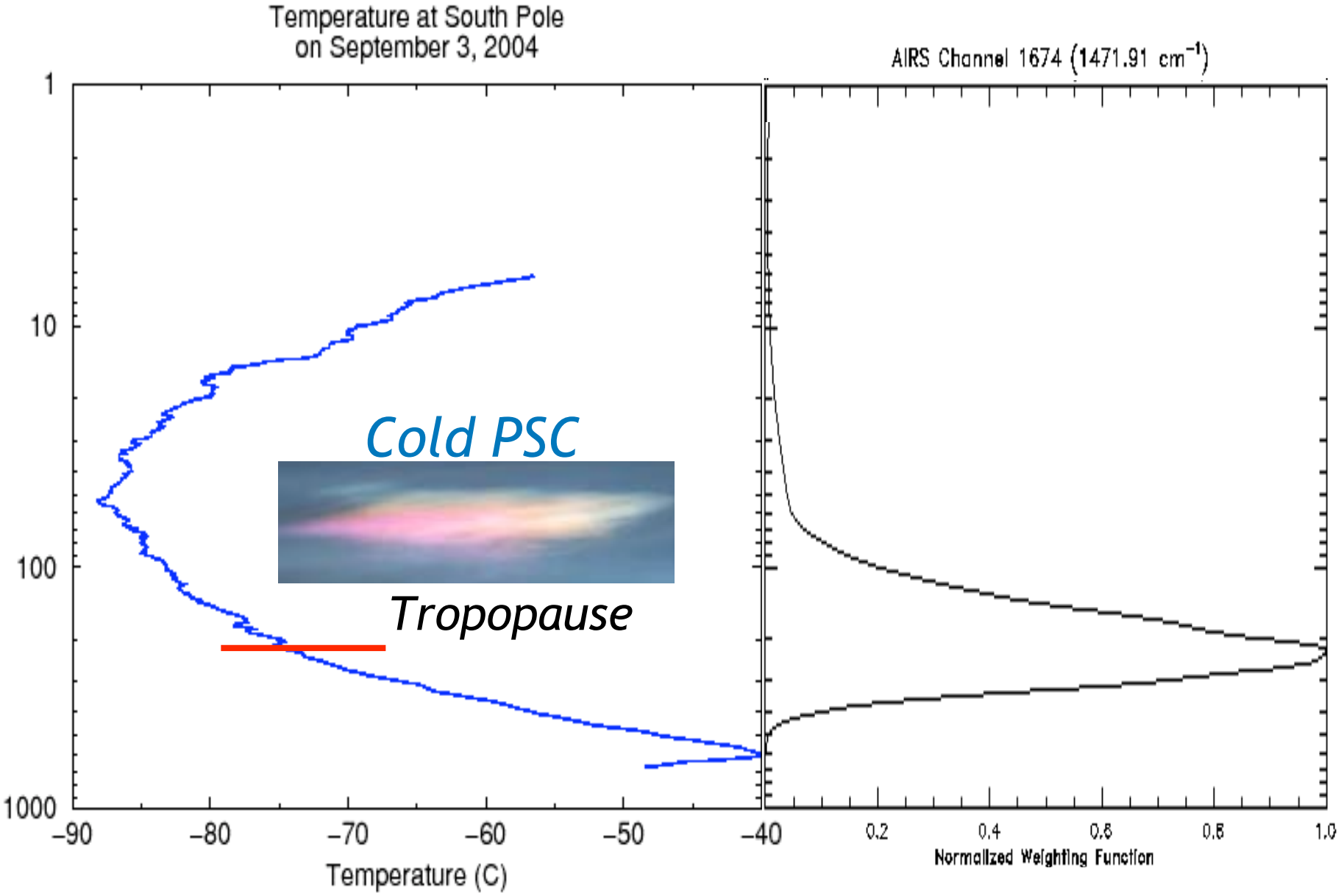
20030115 00z

20030125 00z

Discussion

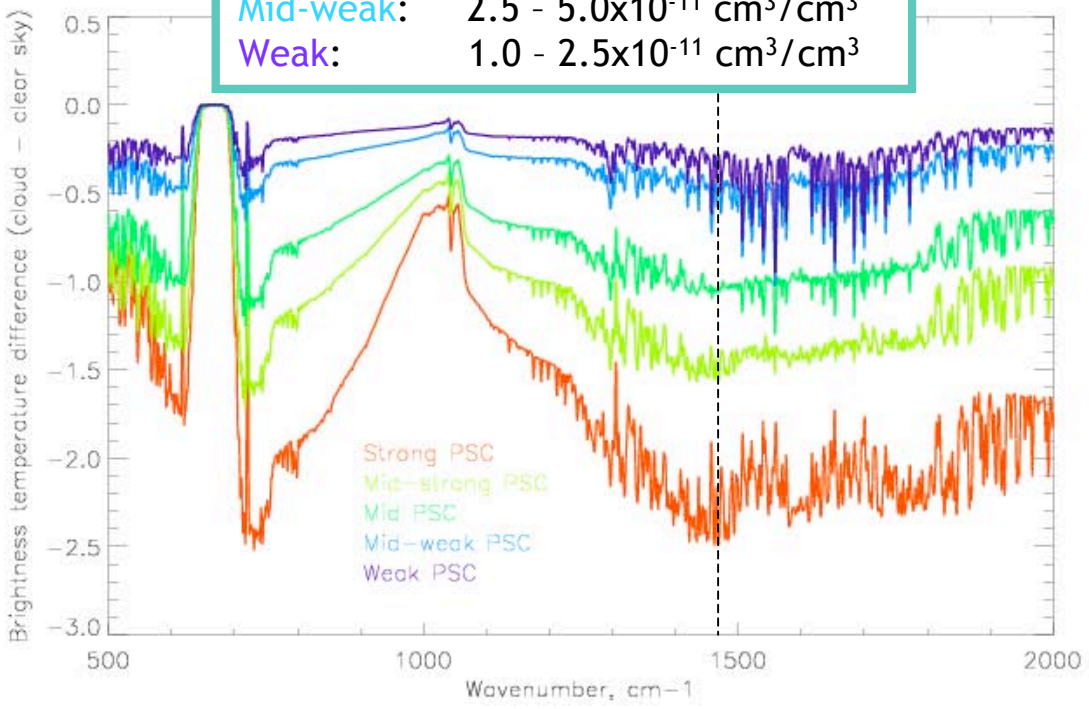
- In spite of attempts to align the two AIRS experiments, still large differences
  - Treatment of clouds conservative for radiances, more aggressive for retrievals
  - Retrieved profiles outnumber radiance profiles by a factor of 4 to 5
  - Radiances are thinned according to operational requirements for computational throughput
  - Retrievals were considered computationally f”ree of charge”
- Additional experiments needed

Expected PSC impact

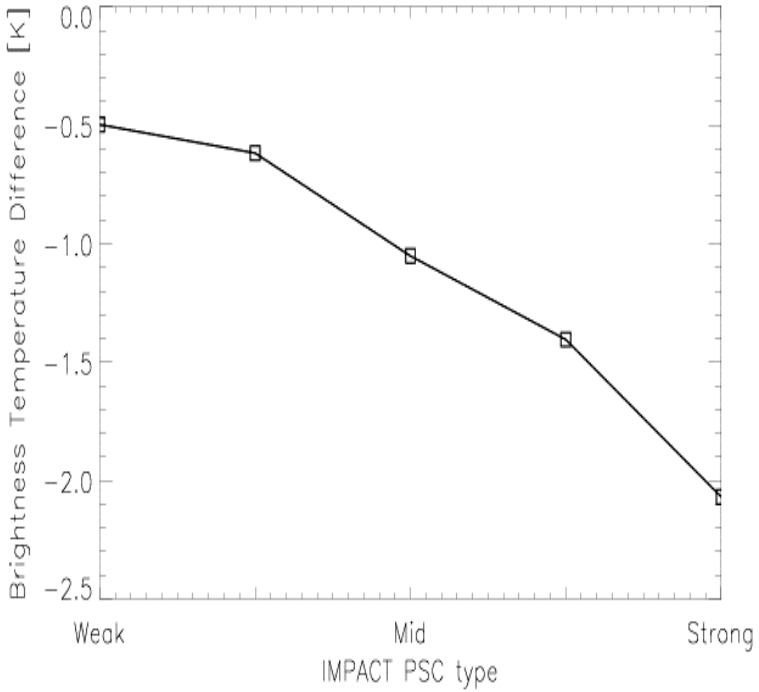


IMPACT/MODTRAN simulation

Strong:	>1.0x10^{-10} cm^3/cm^3
Mid-strong:	7.5 – 10.0x10^{-11} cm^3/cm^3
Mid:	5.0 – 7.5x10^{-11} cm^3/cm^3
Mid-weak:	2.5 – 5.0x10^{-11} cm^3/cm^3
Weak:	1.0 – 2.5x10^{-11} cm^3/cm^3

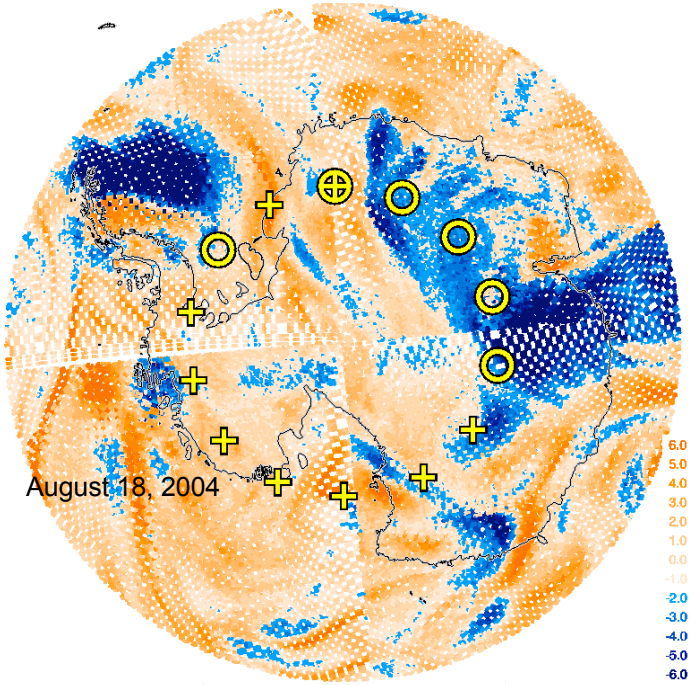


AIRS channel at 6.79 μm

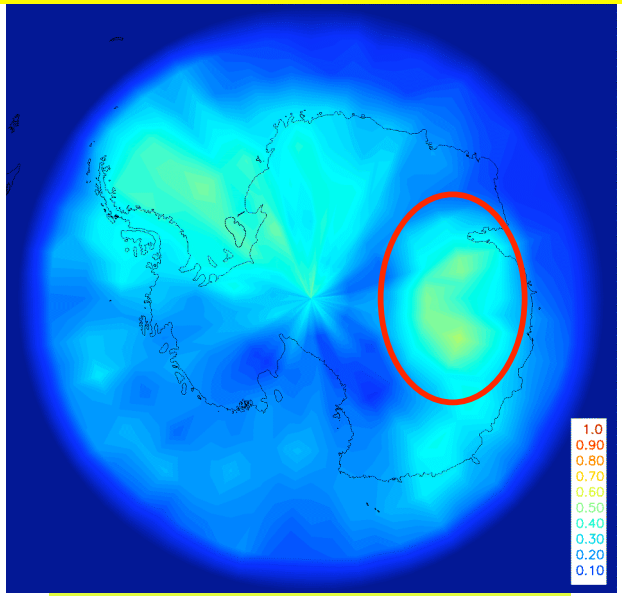


- Combined MODTRAN/IMPACT results indicate decrease in brightness temperature upon introduction of ice PSCs.
- Differences between cloudy and clear sky conditions are shown.

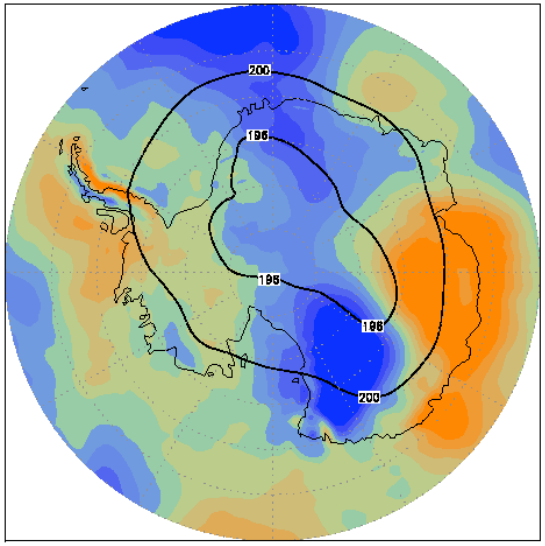
Ice Polar Stratospheric Clouds (PSCs) Detected from Assimilation of Atmospheric Infrared Sounder Data



AIRS observations-minus-**GEOS-5** forecast (O-Fs) for 6.79 μm "moisture" channel. The forecast is computed assuming that clouds are not present. O-Fs lower than –2K (blue) typically coincide with locations where POAM III detected ice PSCs (◎ `



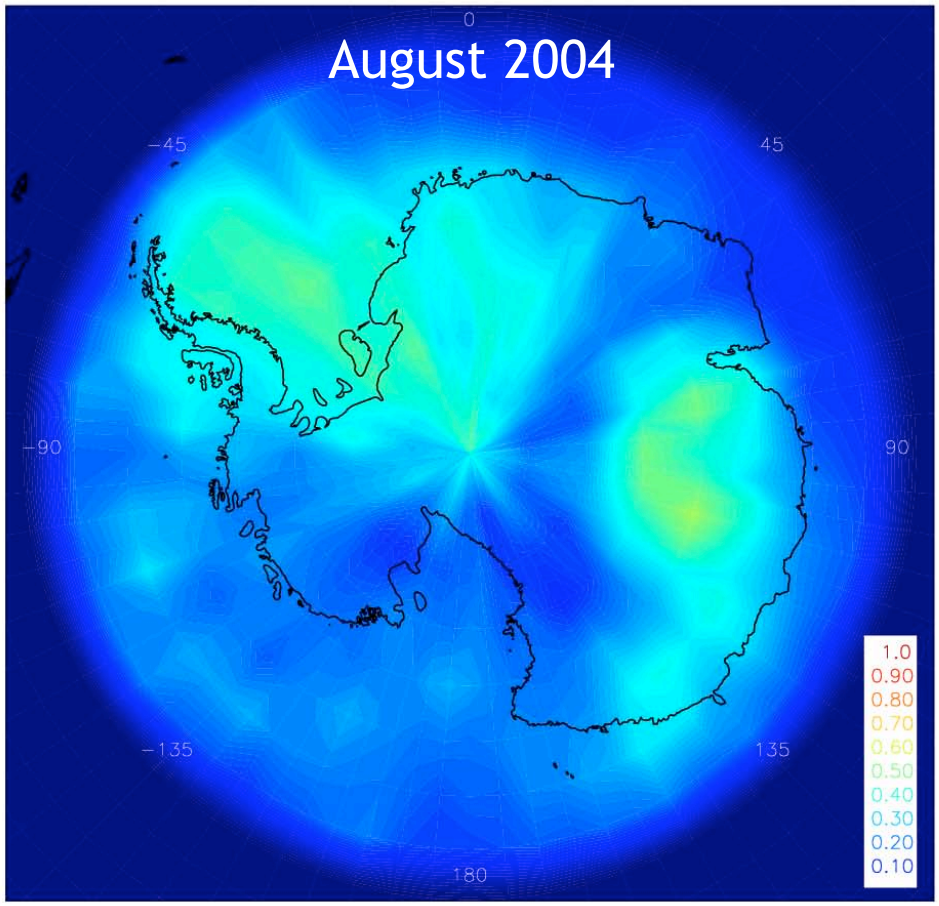
High frequency of AIRS O-Fs lower than -2K indicates frequent ice PSCs in an unusual region during August 2004.

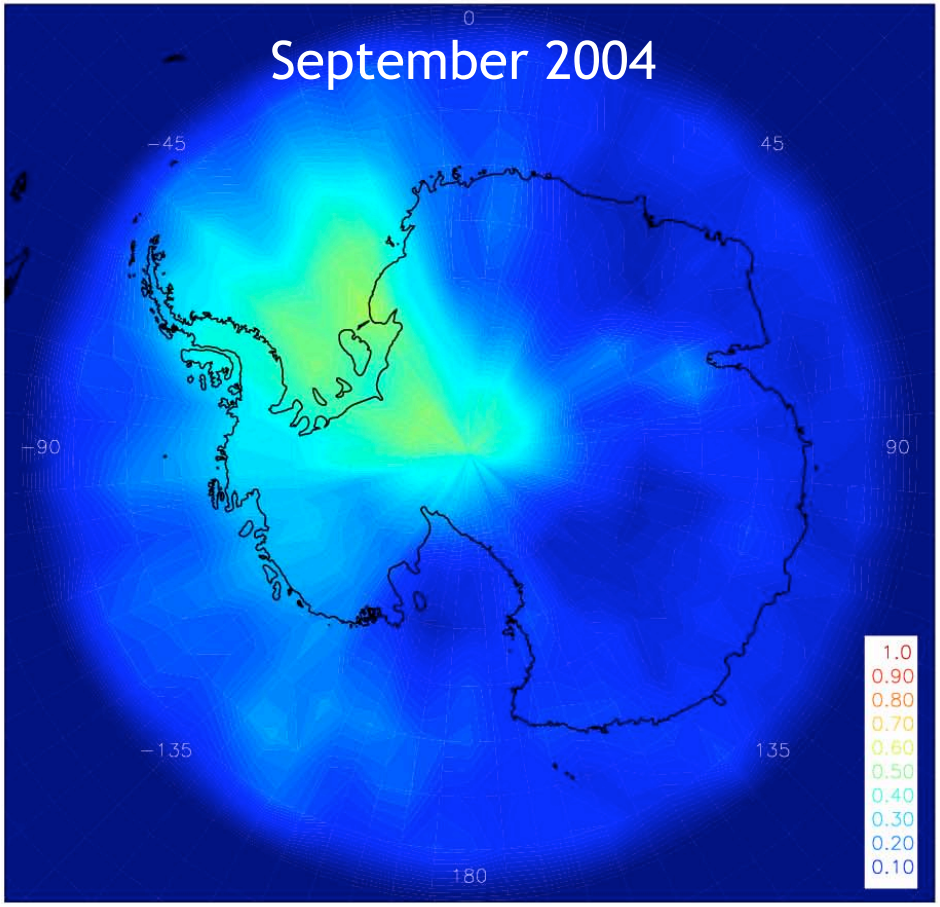


This is a cold region (temperature contours) with frequent upwelling (orange) during August 2004 at 200 hPa over Antarctica.

Stajner et al. (2007), *Geophys. Res. Lett., 34, L16802, doi:10.1029/2007GL029415.*

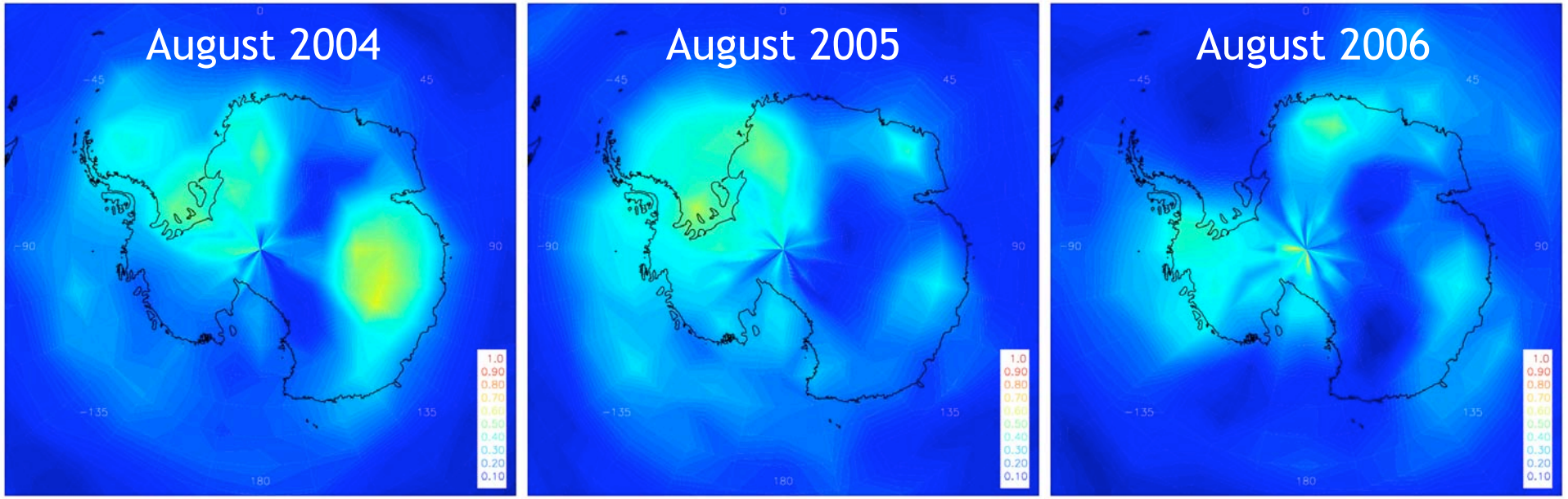
PSC frequency





- O-F residuals over a full month can be used to estimate the frequency of occurrence of ice PSCs.
- PSCs frequently appear downwind of Antarctic Peninsula, but also close to 90^{o} E in August.

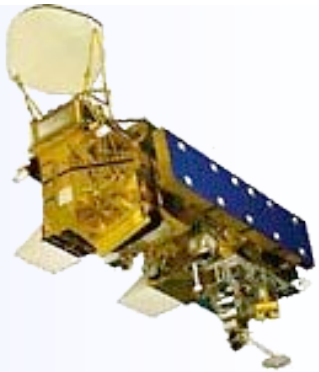
PSC frequencies from thinned AIRS data



- Annual changes in PSC frequency distribution evident from thinned AIRS O-F residuals
- High degree of variability in longitudinal dependence of PSCs
- Data can lead to a detailed climatology, insight into PSC formation when coupled with wind and temperature fields

Summary

- AIRS is doing well both for NWP and other applications in the JCSDA and elsewhere
- NWP impact still based on relatively conservative approach to assimilation
- Both retrievals and cloudy radiances are being studied



AIRS Data Assimilation

Using Cloudy Fields of View

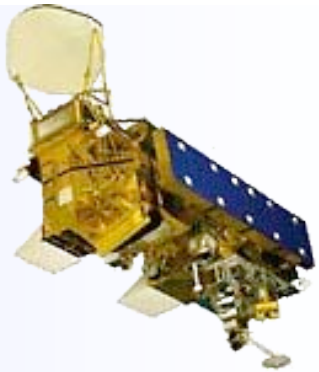
Initial Experiments: 1 January – 24 February 2007

Assume :

$$R_j = (1 - \alpha_j) R_{clr} + \alpha_j R_{cld}$$

Only variability in AIRS fov is cloud amount α_j

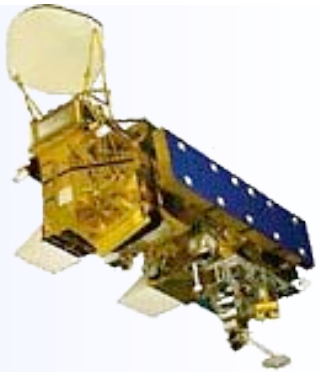
9 AIRS fovs on each AMSU-A footprint used to estimate R_{clr}



AIRS Data Assimilation

Using Cloudy Fields of View

Susskind, J., C.D. Barnet and J.M. Blaisdell 2003. Retrieval of atmospheric and surface parameters from AIRS/AMSU/HSB data in the presence of clouds. IEEE Trans. Geosci. Remote Sens., 41, 390-409.



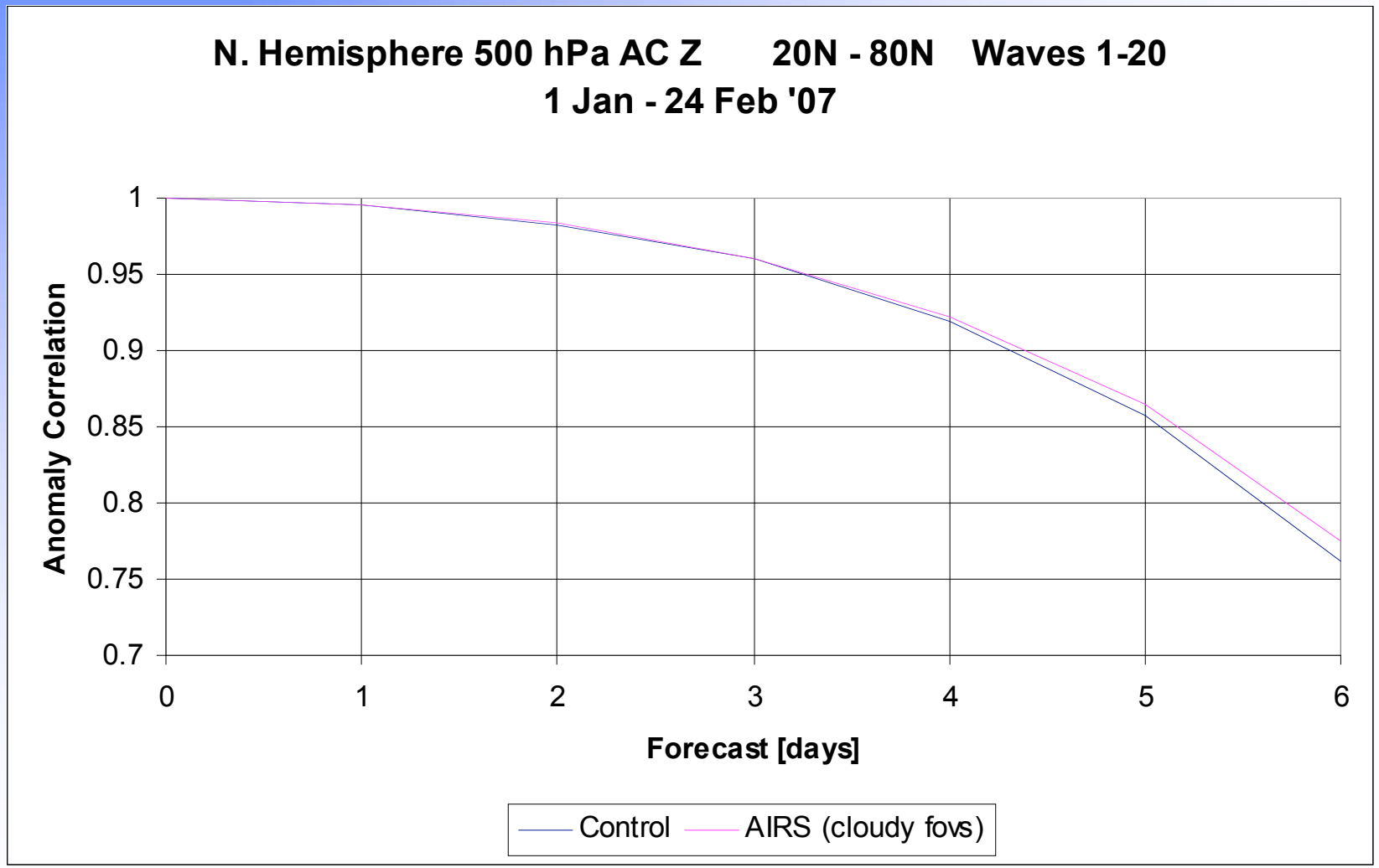
AIRS Data Assimilation

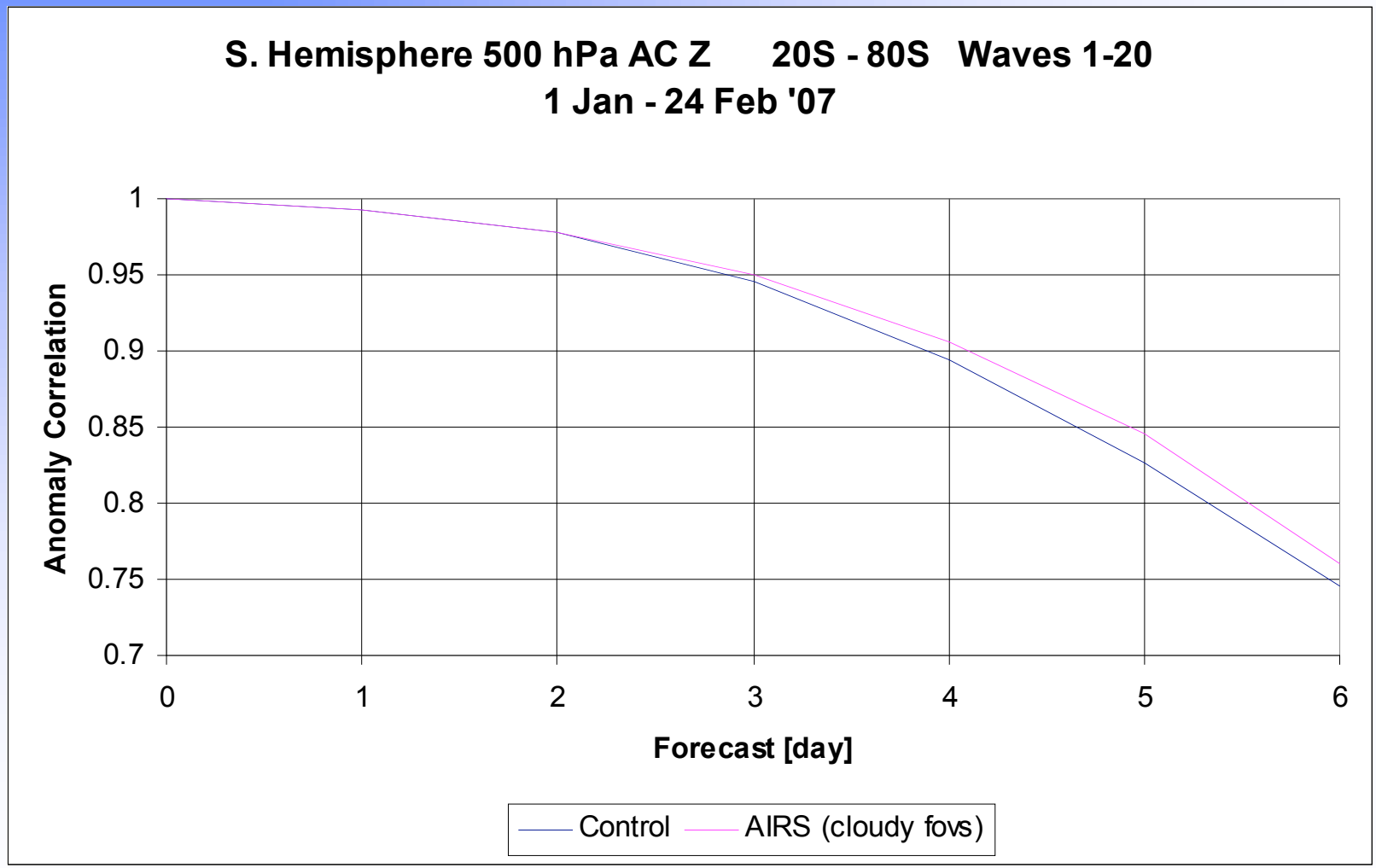
Using Cloudy Fields of View

Initial Experiments: 1 January – 24 February 2007

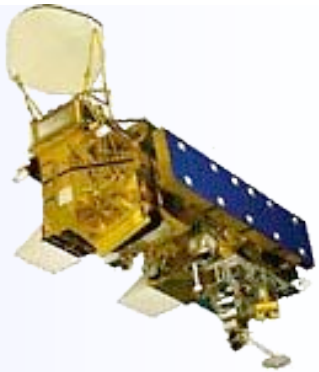
Control – Current Ops. (OP. data coverage - Uses 152 AIRS channels from all fovs with operational thinning)

Experiment- Op. data coverage, minus Op. AIRS plus AIRS radiances from channels free from cloud effects and radiances from the clear air part of selected cloudy fovs (with operational thinning).


N. Hemisphere 500 hPa AC Z 20N - 80N Waves 1-20
1 Jan - 24 Feb '07
Anomaly Correlation
1
0.95
0.9
0.85
0.8
0.75
0.7
0
1
2
3
4
5
6
Forecast [days]
Control
AIRS (cloudy fovs)


S. Hemisphere 500 hPa AC Z 20S - 80S Waves 1-20
1 Jan - 24 Feb '07
Anomaly Correlation
1
0.95
0.9
0.85
0.8
0.75
0.7
0
1
2
3
4
5
6
Forecast [day]
Control
AIRS (cloudy fovs)

AIRS Data Assimilation Using Cloudy Fields of View



Initial Experiments: 1 January – 24 February 2007

Results:

Assimilation of radiances from cloudy fovs resulted in improved anomaly correlations for the experimental system during the period studied.